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Plans for AIRS V6 Validation and Testing

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AIRS Science Team Meeting, Caltech

22 April 2010

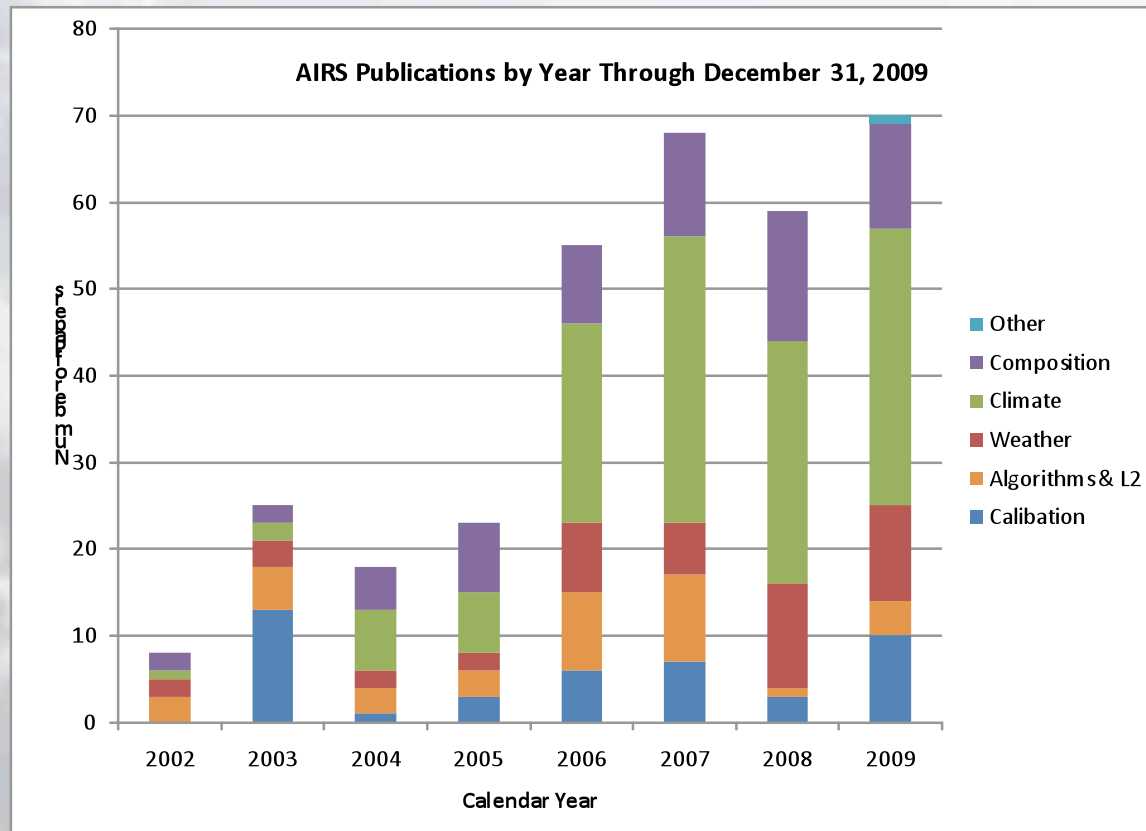


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Why validation still matters

- **Scientific use of AIRS products is increasing.**
 - *Shown in many talks this week.*
- **Emphasis on regional climate in IPCC fifth assessment.**
 - *AIRS can be the standard.*
 - Joao Teixeira is working toward this goal.





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Validation Table

AIRS Product	Uncertainty Estimate (Version 5)	Val Status (Version 5)	Source
Radiances			
AIRS IR Radiance	<0.2%	Stage 3	Project
AIRS VIS/NIR Radiance	15-20%	Stage 1	Project
AMSU Radiance	1-3 K	Stage 3	Project
HSB Radiance	1-3 K	Stage 3	Project
Core Products			
Cloud Cleared IR Radiance	1.0 K	Stage 2	Project
Sea Surface Temperature	1.0 K	Stage 2	Project
Land Surface Temperature	2-3 K	Stage 1	Project
Temperature Profile	1 K / km	Stage 2	Project
Water Vapor Profile	15% / 2km	Stage 2	Project
Total Precipitable Water	5%	Stage 2	Project
Fractional Cloud Cover	20%	Stage 2	Project
Cloud Top Height	1 km	Stage 2	Project
Cloud Top Temperature	2.0 K	Stage 2	Project
Necessary Products*			
Total Ozone Column	5%	Stage 2	Project
Ozone Profile	20%	Stage 2	Project
Land Surface Emissivity	10%	Stage 1	Project
IR Dust**	0.5 K	Stage 1	Project
Research Products			
Carbon Monoxide	15%	Stage 2	NOAA/UMBC
Methane	2%	Stage 1	NOAA
Carbon Dioxide**	1-2 ppm	Stage 1	NASA/NOAA
OLR	5 W/m2	Stage 1	GSFC
HNO3**	0.2 DU	Stage 1	NOAA/UMBC
Sulfur Dioxide**	1 DU	Stage 1	NOAA/UMBC

*Necessary Products are required to retrieve accurate temperature profiles (1K/km) in all conditions

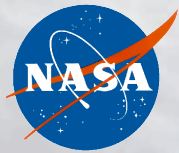
**Product not yet available in AIRS Level 2 Files. Products will be available in Version 6

Validation Status Definitions (Common to all Aqua Instruments)

Stage 1: Validation Product accuracy has been estimated using a small number of independent measurements obtained from selected locations and time periods and ground-truth/field program effort.

Stage 2: Validation Product accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.

Stage 3: Validation Product accuracy has been assessed, and the uncertainties in the product well-established via independent measurements made in a systematic and statistically robust way that represents global conditions.



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Atmospheric Infrared Sounder

Validation and Testing Current assets (incomplete list)

- **Operational sonde database**
- **Dedicated sonde database**
- **GPS for $T_{\text{air}} < 250 \text{ K}$**
- **ECMWF profiles**
- **AMSR-E SST and water vapor**
- **OMI total ozone, ozonesondes**
- **CloudSat/CALIPSO**
- **Surface station data**
- **Aircraft campaigns**



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Radiosonde Data Base

- **Atlas of dedicated radiosondes in common format.**
- **Add operational sondes for temperature bias trending.**
 - *Supplement dedicated sondes in E. Europe and Pacific where 0,12Z = 1:30 local time.*
- **Why?**
 - *Validation: constrain AIRS accuracy and precision.*
 - *V6 testing*
 - To supplement ECMWF comparisons.
 - **Can we replicate tests as done by Thomas Hearty for V3, V4, and V5?**



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Dedicated sonde coverage by geophysical regime

1. Tropics are well covered

- **ARM TWP, OCEAN**
- **Minnett sondes, OCEAN**
- **Nalli sondes from AEROSE, OCEAN**
- **Costa Rica, Aura Validation Experiments (AVE), LAND**
- **Puerto Rico (AVE?), MIXED**
- **Andros, Bahamas, OCEAN, SON**
- **RICO Experiment, Caribbean OCEAN, DJF**
- **San Cristobal, Galapagos, OCEAN, DJF**
- **Ascension Is., E. Trop. Atl., OCEAN, DJF**
- **Natal, Brazil, LAND, DJF**

Green = bias only (N ~ 10), 1 Season

Blue = bias, variance (N~20), 1 Season

Red = bias, variance, >1 Season



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Coverage by geophysical regime

2. Middle Latitudes well covered at 1 land site.

- *ARM Southern Great Plain, LAND, All seasons*
- *Beltsville, Maryland, LAND, JJA*
- *Chesapeake Light Platform, OCEAN, SON*
- *Garmisch, Germany, LAND, SON*
- *Toulouse, France, LAND, SON*
- *Table Mountain, So. California, SON*

3. Polar Regions have limited sonde coverage.

- *ARM NSA, MIXED, All seasons*
- *Dome C, Antarctica, LAND DJF*



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Summarizing *dedicated* sonde sites

We have 30 total sites, consisting of:

- **7: 'Supersites' with >20 sondes for multiple seasons.**
- **8: Good sites with >20 sondes for 1 season.**
- **3: Okay sites with ~10 sondes for 1 season.**
- **12: poor sites with too few sondes**
 - *May be useful for global bias constraints.*
- **Some climate conditions are poorly sampled. For example:**
 - *Only Table Mountain, CA is near a continental desert.*
 - *Few sondes over extensive tropical forests like Amazon, Congo, Indonesia.*
 - *Few sondes at middle and high latitude oceanic sites.*
 - Dedicated sondes over Pacific may help.



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Validate to five (six?) geophysical regimes

1. Frozen land and ocean.
2. Non-frozen ocean: low latitude
3. Non-frozen ocean: high latitude.
4. Non-frozen land: low latitude
5. Non-frozen land: temperate
6. Non-frozen land: desert???

Not enough sites to subdivide these classes further.

— *with exceptions, like SST.*



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V6 products to be tested

- **Temperature profile**
- **Water vapor**
- **Cloud fraction, cloud-top pressure**
- **Total ozone**
- **Sea surface temperature**
- **Land surface emissivity**
- **Error bars**
- **Bias trends**

This will be quite different from V5 testing since the bulk of the comparisons will be against measurements, not ECMWF.



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Conditions for V6 Testing (Same as V5)

- **Geophysical conditions:**
 - *Five (or six).*
- **Quality flag conditions:**
 - *Qual_* = 0 or 1*
 - *retrieval_type \diamond 100*
- **Resolution for test purposes:**
 - *Temperature from support product levels (TAirSup)*
 - average in 1 km thick layers below 700 mb
 - 2 km thick layers from 700 to 30 mb.
 - *Water will be converted to 2km thick layers in troposphere.*
 - *Same procedure for correlative data.*
 - *NOTE: does not exploit averaging kernel info.*



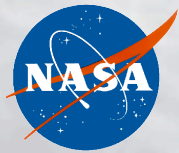
Proposed Tests

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- **Bias test**
 - **Calculate mean or median difference between AIRS and correlative data**
- **RMS test**
 - **Calculate root-mean-square of difference between AIRS and correlative data**
- **Chi-square test**
 - **Calculate weighted residual between AIRS and correlative data, e.g.:**

$$\chi^2 = \frac{1}{N} \sum_{i=1}^N \left(\frac{T_{\text{AIRS}} - T_{\text{sonde}}}{\text{err}_{T_{\text{AIRS}}}} \right)^2$$

- **Yield test**
 - **Calculate yield under different geophysical conditions.**
 - Test that Qual_* parameters are consistent with error estimates (e.g., the lowest error estimate for Qual_* = 1 is higher than the highest error estimate for Qual_* = 0, etc.)
 - Compare to V5 focus days and check for changes and trends in yield
- **Skill Test**
 - **Measure improvement with respect to background climatology.**
Skill = Corr(retrieved – climatology, truth – climatology) * Sqrt(fractional yield)
- **Trend test**
 - **Well-established against radiosondes.**



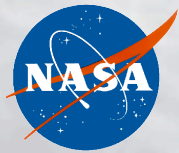
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Specific Parameter tests

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- **Core product tests of Bias, RMS, Skill, Chi-Squared, Yield, Trends**
 - ***Atmospheric temperature***
 - Correlative data: sondes, GPS
 - ***Surface temperature***
 - Correlative data: surface data, AMSR-E
 - ***Water vapor***
 - Correlative data: Sondes, AMSR-E (ocean total water)
 - ***Ozone***
 - Correlative data: OMI, ozonesondes
- **Cloud Parameters**
 - ***Correlative data: CloudSat/CALIPSO***
 - ***The same review process as V5.***
 - ***Use combined CloudSat/CALIPSO cloud profiles to assess the cloud detection, amount, and height products.***
- **Carbon Monoxide, carbon dioxide, methane?**



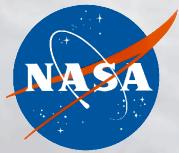
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PGE Tests

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- **L2 Bias Trending**
 - *Compare T_{air} -sonde as a function of time*
- **Retrieval in presence of dust**
 - *Compare T_{air} , H_2O retrieval to sondes in presence of dust*
 - *Success criteria: reduced RMS to sondes and SST.*
 - *Many sondes from Nick Nalli.*
- **L2 New Regression Tuning**
 - *Test Regression T_{air} , H_2OCD , T_{surf} emis similarly to how these are tested for the final.*
 - *Looking for better RMS and skill than V5.*
- **L2 Remove bias tuning**
 - *Skill test.*



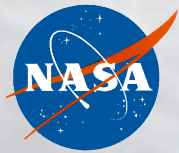
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PGE Tests (con't)

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- **Use Climatology as L2 First Guess**
 - *RMS, yield, trend and skill tests*
- **L2 Emissivity**
- **L2 Boundary Layer**
 - *RMS tests in boundary layer compared with sondes*
- **L2 CO₂ climatology (for clouds and aerosols only)**
 - *RMS, yield, trend and skill tests*
- **L2 AIRS-Only (QA and Error)**
- **L2 Blackwell Neural Network**
 - *L2 Retrieval post effects of Neural Net integration*
- **L2 Regression vs. Neural Net for first guess.**
 - *Which is better? How will it affect Joel's code?*



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Conclusions: Validation and Testing

- **We have a *very* extensive assembly of correlative data sets.**
- **We have a *very* comprehensive set of tests and validation analyses.**
- **We need to triage these to something relevant, manageable, and achievable.**
 - **Role of Deputy Project Scientist (like Gary Cooper in “High Noon”).**
- ***Improvement in V6 must be/is being demonstrated.***